Monograph:

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Response of parental investments to child's health endowment at birth

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Structured Abstract

• Purpose

We estimate the parental investment response to the child endowment at birth, by analysing the effect of child birth weight on the hours worked by the mother two years after birth. Mothers' working hours soon after childbirth are a measure of investments in their children as a decrease (increase) in hours raises (lowers) her time investment in the child.

• Methodology/approach

The child birth endowment is endogenously determined in part by unobserved traits of parents, such as investments during pregnancy. We adopt an instrumental variables estimation. Our instrumental variables are measures of the father's health endowment at birth, which drive child birth weight through genetic transmission but does not affect directly the mothers' postnatal investments, conditional on maternal and paternal human capital and prenatal investments.

• Findings

We find an inverted U-shape relationship between mother's worked hours and birth weight, suggesting that both low and extremely high child birth weight are associated with child health issues for which mothers compensate by reducing their labour supply. The mother's compensating response to child birth weight seems slightly attenuated for second and later born children.

• Originality/value of paper

Our study contributes to the literature on the response of parental investments to child's health at birth by proposing new and more credible instrumental variables for the child health endowment at birth and allowing for a heterogenous response of the mother's investment for first born and later born children.

Keywords: Parental investment; Child birth endowment; Instrumental variables.

This is a Research paper.

Introduction

The health endowment of a child at birth has been found to have long term effects on health and socioeconomic outcomes such as earnings and educational achievements (see Currie 2011). Estimating the parental investment response to child health endowment at birth is important to understand whether channel through which the birth endowment drives later life outcomes is a direct biological effect or whether there is also an amplifying (attenuating) effect of reinforcing (compensating) parental investments. Estimating the parental investment response is also motivated by a wish to understand how parents determine their investments in children.

As a measure of health endowment at birth we will consider birth weight, which is related to the risk of early health issues and infant death as well as to long term health and socioeconomic outcomes; and we consider as measure of parental investment the number of working hours of women 2 years after childbirth. We interpret a decrease (increase) in the mother's worked hours as a rise (reduction) in the time investments in her child. This is because we think that mothers' working hours soon after childbirth are driven by concerns about time investments in their child more than income concerns. This type of interpretation is supported by the fact that (i) there is some empirical evidence for a negative effect of women working hours on child outcomes (e.g. Bernal 2008)[4], (ii) the literature has found that time investments of parents are highest in early childhood and falling across age (Del Boca, Flinn and Wiswall 2014, Guryan, Hurst and Kearney 2008, Zick and Bryant 1996) whilst financial investments tend to increase as children age (Kornrich and Furstenberg 2013).

Identifying the causal effect of the child birth endowment on parental investments is challenging. The endowment may not be exogenous because it is determined by unobserved traits of parents during pregnancy, for example parental prenatal investments and genetic traits, which can affect parental post-birth investments (see Almond and Mazumder 2013).

[4] Other studies looking at the causal effect of mother's labour supply on child's outcomes are Blau and Grossberg (1992), Carneiro, Loken, Salvanes (2011), Danzer and Lavy (2013), Del Boca et al. (2014), and Baker and Milligan (2015).

Most previous papers looking at the relationship between child health and mother labour supply neglect the issue of endogeneity of child health.[5] The studies of Corman, Noonan and Reichman (2005), Zimmer (2007) and Frijters, Johnston, Shah and Shields (2009) are exceptions which take account of endogeneity by considering instrumental variable estimation. Corman et al. (2005) instrument an indicator of child poor health in early years with the number of adoption agencies per population in the city where the child was born (as a measure for the wantedness of the birth) and availability of a high quality neonatal intensive care in the hospital where the child was born (as a measure of hospital quality). Zimmer (2007) use as instrumental variables three self-reported measures of difficulty in access to health care and estimate the effect of child poor health (measured on a 5-point scale reported by the parent) on mother labour supply. Frijters et al. (2009) estimate the effect of child development at age 4-5 (a composite index which is based on the sum of indicators of poor emotional, learning, language, gross motor and fine motor development) on mother's labour supply taking into account the endogeneity issue by using child handedness as an instrument for child development.

Contrary to these previous papers, we measure the reaction of mothers to the health endowment at birth rather than in early childhood. The advantages in using health at birth are (1) we reduce the potential issue of unobserved heterogeneity because outcomes at birth can be influenced only by prebirth inputs; (2) there is no issue of reverse causality which typically affects studies looking at child health in early life when the mother's postnatal labour supply decisions have already been taken.

Our study differs from these three previous papers also because we propose new and more credible instrumental variables for the child health endowment. We consider measures of the father's health endowment at birth as instruments for child health endowment at birth.

Validity of the fathers' health endowment at birth as instrumental variable for child birth weight requires the usual assumptions of relevance and exclusion restrictions. Genetic trans-

[5] Among studies looking at this relationship there are Salkever (1982), Wolfe and Hill (1995), Powers (2001) and (2003), and Kvist et al. (2013).

missions across generations will ensure that the father's health endowment at birth is relevant in explaining the child birth endowment. In addition, the father's health at birth does not explain the mother's post-birth investment decisions except through two mechanisms. The first mechanism is assortative mating by traits linked to health endowments at birth and we control for the mother's health endowment at birth to eliminate this endogeneity bias. The second mechanism is human capital, where the birth endowment of a father drives his human capital acquisition, which may explain the postnatal investment decisions of the mother. We control for this potential bias by including a set of covariates including the father's education, earnings and work status and the mother's health endowment at birth, education and work status in the year before birth.

The instruments we propose are readily available in a large set of datasets and arguably more credible than those used in existing studies for three reasons; (1) the variance of our instruments is not limited to variation between hospitals and areas like in Corman et al. (2005); (2) our measures of father's health at birth, our instrumental variables, are objective measures of health rather than self-reported subjective measures which can lead to a spurious correlation, like in Zimmer (2007); (3) the health at birth of the father is likely to be more relevant in explaining child health at birth than previous proposed instruments, such as the handedness of a child adopted by Frijters et al. (2009).

By exploiting very detailed information available in the Norwegian administrative data we are able to use objective measures of child health which are less prone to measurement errors than subjective measures. We can also control for a rich set of characteristics of the mother and father which would otherwise confound the effect of child health on the mothers' investments.

We check the validity of our instruments by testing whether the father's health endowment at birth is correlated with prenatal maternal investments (prebirth smoking habits and labour participation), and by implementing the Hansen-Sargan test for overidentification using two measures of the fathers' health at birth - birth weight and fetal growth (birth weight per week of gestation) - which have been shown to be predictive of their child's health outcomes (Currie and Moretti 2007).

Our main findings can be summarized as follow: (i) using instrumental variables estimation we find an inverted U-shape relationship between mother's worked hours and birth weight, which confirms the expectation that both low and extremely high child birth weight is associated with child health issues for which mothers compensate by reducing their labour supply; (ii) the mother's compensating response to child birth weight seems slightly attenuated for second and later born children. These results are in line with Corman et al. (2005) and Frijters et al. (2009) who measure health endowment in early childhood rather than at birth.

Clearly the mother's labour supply is just one of the parental investments in early childhood which can be relevant for the child's outcome. Studies that have looked at other measures of parental investments have not reached a consensus yet (see Almond and Mazumder 2013).

The work is structured as follows. Section 2 presents the conceptual economic theoretical framework and the econometric estimation adopted for the investment model. Section 3 provides details the data, while section 4 reports our empirical results and we provide some conclusions in section 5.

Parental Investment Model

Conceptual framework

An economic literature, relating to intrahousehold resource allocation and intergenerational mobility, has explored the expected parental investment response to child endowments (see Becker and Tomes 1979 and 1986, Solon 1999, Björklund and Salvanes 2011). We now provide a summary of the predictions of these models.

In a model where parents make investment decisions across multiple stages of child development, parents face an inequity-efficiency trade-off when choosing between a compensating or a reinforcing investment strategy. If there is complementarity between the parental investment in one stage and the child's endowment in the previous stage, then a high human capital endowment at a specific stage can increase the productivity of parental investment in the following stage. This would indicate a reinforcing strategy of parents. However, the response of parental investments may also depend on specific parental preferences captured by their utility function. If the marginal utility of parents is diminishing in the child's human capital, then parents may reduce their investments in reaction to an increase in their child's human capital. If the utility of parents depends on the inequality between their own and their child's endowments because for example they are averse to intergenerational inequity in endowments, then their utility may increase when adopting a compensating investment strategy. They would invest more when their child performs below their standards and less when the child performs above their standards.[6] The sign of the effect of the child's endowment on parental investments is ambiguous (see Yi, Heckman, Zhang, and Conti 2015 and Nicoletti and Tonei 2017) and ultimately an empirical question to investigate.

Econometric strategy

The response of parental investments to the child health endowment at birth has attracted a lot of attention by economists. However identifying and estimating the causal effect on parental investment is challenging (see Almond and Mazumder 2013). The main econometric issue is that the child health endowment at birth is in part explained by genetic transmission of parental health endowments and in part explained by environmental factors while in the womb. In particular maternal health investments during pregnancy are likely to drive both the child endowment and subsequent post-birth investments. Without adequate control for maternal investments during pregnancy, estimation of the responsiveness of post-birth investments to the child endowment will be biased.

An econometric strategy widely used by previous empirical papers to address this endogeneity relies on samples of siblings. Two possible strategies are to assume i) a family fixed effect estimation and that there are no differences in prenatal investments between siblings

[6] (See Becker and Tomes 1979 and Behrman et al. 1982 for the two opposite theoretical suggestions)

or ii) a family fixed effect estimation combined with instrumental variables to correct for any potential residual endogeneity in the sibling difference in endowments at birth (see Rosenzweig and Wolpin 1988 and 1995; Royer 2009; Datar, Kilburn and Loughran 2010; Currie and Almond 2011; Aizer and Cunha 2012;[7] Del Bono, Ermisch and Francesconi 2012; Hsin 2012; Restrepo 2016).[8]

An alternative econometric strategy to estimate the investment response considers a source of exogenous variation in child health from natural or man-made shocks to the health environment while the child was in the womb. Examples include flu epidemics[9] and radioactive accidents[10]. A similar strategy exploits exogenous discontinuities in prenatal or neonatal health care provision which cause differences in health between children with almost identical starting health endowments[11]. The limitation of such estimation strategies is that there can be a direct effect of the health care treatment or of the specific health shock on parental investments, meaning that the estimated investment response is only relevant to the specific context.

In our application, we estimate the effect of child health at birth on mothers' labour supply. We worry about endogeneity caused by the omission of mother's genetic traits and of unobserved inputs during pregnancy because these unobservables explain child birth weight and can be related to the mother working hours after childbirth. The endogeneity bias caused by unobserved genetic traits can be eliminated through controls for the mother's birth weight. On the contrary, because it is difficult to control exhaustively for prenatal investments (for example mother's smoking, drinking, food habits, health style, nutritional

[7] Aizer and Cunha (2012) use a mix of approaches including factor models.

[8] For a complete review of papers see Almond and Mazumder (2013).

[9] Parman (2012) and Kelly (2011) show that there is an effect of flu epidemics on child's health, therefore epidemics could be used to identify exogenous variation in child's health to evaluate the investment response of parents.

[10] Almond et al. (2009), Black et al. (2013) and Halla and Zweimüller (2014) look at the effect of radioactive fallout during pregnancy on children's outcomes and some of them find signficant effects. Halla and Zweimüller (2014) evaluate the effect of radioactive fallout also on the investment response of parents and find that parents adopt a compensating behaviour.

[11] Almond et al. (2010) and Bharadwaj et al. (2013) find that differences in neonatal care provided to children with a birth wieght just below and just above 1500 grams lead to differences in health outcomes and improved cognitive development, which could lead to a reaction of parental investments.

supplements intakes, health conditions, labour participation, number of working hours, etc.), there can be some residual endogenous variation in the child's birth endowment.

Our strategy to control for the unobserved heterogeneity is firstly to control for observed mother traits, in particular her birth weight, and measures of prenatal investments and secondly to use an instrumental variables method to correct for the potential bias caused by any residual unobserved heterogeneity. The instrumental variable we suggest to use is the birth weight of the father, which determines his child's birth weight through genetic transmission, but which is uncorrelated with unobserved intrauterine investments which are related to unobserved health conditions and health behaviour of the mother during pregnancy.

There has been established an intergenerational transmission of parental health at birth to their children (Currie and Moretti 2007) and as such we expect that father's health at birth will be a strong determinant of the child's health at birth. To satisfy the assumptions of instrumental variables, the instruments must be excludable from the parental investment equation. The father birth endowment should have no direct effect on the investment decisions of mother around birth. Note that we do not assume that the instruments be independent of the postnatal investments given the child health endowment at birth, but we assume that this independence assumption holds conditional on a set of control variables.

Assortative matching may lead to a correlation between the father birth endowment and the mother birth endowment, which in turn can affect her postnatal investment. Nevertheless, after controlling for the mother's birth endowment this potential issue should be resolved. It is also possible that the health endowment of a father will drive the maternal post-birth investments if it drives his human capital outcomes, for example his wage and education. We therefore control for a wide set of measures of the father's human capital, including his education, age at birth, income and work status in the year after birth (when the mother is making decisions about the post-birth investment) as well as for mother's education, age at birth, work status one year before birth and her smoking habits at the start and end of pregnancy. Conditional on these characteristics, there should be no direct link between the father's birth endowment and the mother's working hours after childbirth .

The post-birth maternal investment ($PostI_i$) for mother (or child) i is measured by the number of weekly hours the mother worked two years after childbirth. We do not include working hours at age 1, as it is strongly related to maternity leave entitlement and it is prone to measurement error. The source of measurement error comes from the data recording hours worked in the November of each year, which means that one year after birth the age of the child in November varies between 11 months (for December births) and 22 months (for January births). Nicoletti, Salvanes and Tominey (2016) explain that the hours reported one year after birth vary largely by the month of birth as mothers re-enter the labour market. However when measuring labour supply in subsequent years, the change in labour supply flattens out and measurement error is not important. We do not consider working hours more than two years after childbirth because later decisions on labour supply could be influenced by the birth of another child and most of the Norwegian women wait at least two years before giving birth to another child.

Because both low and extremely high birth weight are related to child health issues, we expect a non-linear relationship between the child's birth weight and the investment response of mothers (see Bharadwaj, Loken and Neilson 2013) and so we consider a quadratic in child birth weight (BW_i and BW_i^2). Furthermore, because we can expect the investment response of mothers to be attenuated by the presence of multiple children we estimate separate models for the mother's worked hours after the birth of their first child and after the birth of the later children. Our regression of postnatal working hours on health endowment at birth is given by:

$$PostI_i = \alpha_0 + BW_i\ \alpha_1 + BW_i^2 \alpha_2 + \boldsymbol{X}_i \boldsymbol{\alpha}_X + \boldsymbol{PreI}_i \boldsymbol{\alpha}_{\boldsymbol{PreI}} + u_i \tag{1}$$

where $\boldsymbol{X}_i$ is a vector of covariates measuring parental socioeconomic status, demographics and proxies for genetic endowments; $\boldsymbol{PreI}_i$ is a vector of proxies for prenatal investments which may determine jointly child health endowments and the maternal postnatal investment; u_i is the error term which we assume to be identically and independently distributed across children (mothers) but potentially correlated with the birth weight of the child. More specifically, the vector $\boldsymbol{X}_i$ includes the mothers' birth weight and gestation; mother's age at the birth (in levels and squared) and education; mother smoking behaviour (measured by cigarettes smoked at the start of pregnancy); father's age at the birth, education, earnings and work status in the year of birth; number of children; and dummy variables to control for child month and year of birth and child gender. The vector $\boldsymbol{PreI}_i$ includes the number of cigarettes smoked at the end of pregnancy and prenatal working status of the mother.

Even conditioning on the genetic endowments, parental socioeconomic status and prenatal investments, there may be unobservable parental traits, such as unobserved mother's health conditions which can be correlated with both the post-birth investments and the child's birth weight. To correct for this remaining unobserved heterogeneity we adopt an instrumental variables method, the two-stage least squares estimation (2SLS estimation). For each of our two endogenous variables, $[BW_i, BW_i^2]$, we estimate a first-stage equation of the endogenous variable on all exogenous controls from model (1) plus a vector of instrumental variables given by the father's birth weight, FBW_i in levels and squared,

$$ChildE_i^k = \beta_0^k + \boldsymbol{X}_i\boldsymbol{\beta}_X^k + \boldsymbol{PreI}_i\boldsymbol{\beta}_{\boldsymbol{PreI}}^k + \mathbf{Z_i}\boldsymbol{\beta}_Z^k + \varepsilon_{i,t}^k \tag{2}$$

where $\mathbf{Z_i} = [FBW_i,\ FBW_i^2]$, $ChildE_i^k$ is one of the two endogenous measures of child endowment at birth (BW_i, BW_i^2) and the superscript k is the indicator associated with each of these 2 endogenous variables.[12]

This instrumental variable estimation we propose can be extended to other types of investments such as breast feeding initiation and time a mother spends with her new born child. Furthermore, it can be extended to joint parental investments (e.g. child care choices and immunization decisions) by considering as instrument, rather than the father's birth

[12] We also estimate a regression using two additional instruments that are father's fetal growth and its square to test the validity of our instruments with an overidentification test.

weight, the birth weight of family members who do not belong to the child's household, for example grandparents, uncles or aunts, and controlling for the birth weight of both parents. Grandparents, uncles and aunts share some of their genes with the child so that we expect their birth weight to be correlated with the birth weight of the child. Because there is empirical evidence that the birth weight is transmitted from one generation to the next,[13] the birth weight of family members outside the household can be powerful instruments to explain the child birth endowment. On the other hand, we do not expect the birth weight of family members outside the child's household to be correlated with the prenatal investments which are related to the mother's behaviour during pregnancy. Nevertheless, because health endowments at birth might be related to health conditions which are transmitted from one generation to the next through in utero environment, maternal family members might share similar health behaviours and health conditions with the mother and this can lead to an estimation bias. It is possible to eliminate this bias by controlling for the mother's health endowment at birth and/or by restricting the family members to the paternal branch.

An additional example application of our instrumental variable estimation is the evaluation of the effect of health endowment at birth of adopted children on investments of their adoptive parents using as instruments measures of health endowments of the biological parents. This type of strategy works well under the assumption that adopted children are randomly assigned to parents or, in the case of a non-random assignment, if the estimation model is conditional on all potential characteristics that are correlated with the assignment of children and the investments by the adoptive parents.

Data

Data and sample selection

Our data comes from the Norwegian administrative register data for the period 1960-2010, collected and maintained by Statistics Norway. The administrative data uniquely links the population of Norway across different registers and across time. Our sample is all births

[13] See Currie and Moretti 2007 and Royer 2009 for birth weight transmission and Thompson 2014 for the transmission various chronic health conditions.

in Norway in the years 2005-2006. Births in this time period allow us to identify historical information on the births of the parents as well as sufficient information on maternal labour force participation two years after birth. For 2005-2006 births, the oldest mother for whom we can observe birth records is 38 and 95% of mothers are 38 or younger at birth.

The child endowment is measured by birth weight in 100 grams recorded on the birth certificate. The birth register provides information additionally on the month and year of birth and the age of parents at birth. We merge birth weight and gestation of the mother and the father, taken from their respective birth certificates.

Our dependent variable, maternal investments after childbirth is constructed from a measure of weekly hours worked by the mother from the labour market register. Hours are recorded as a discrete variable taking the values of 0, 1-19, 20-29 and 30+. Similarly to Nicoletti et al. (2016) we create a variable for hours in each year by taking the mid-point of these categories, recording hours as 0, 10, 24.5 and 40 as the final category which represents a full-time contract in Norway. Our outcome variable is the hours worked 2 years after birth. We exclude the first year after birth because of maternity leave eligibility during this period and measurement error (see Section 2).

We take from the administrative register the education level of both parents and father's earnings and employment status in the year of birth.

Finally, we consider a set of prenatal maternal investments by measuring the number of cigarettes the mother smoked the end of pregnancy[14] and a measure of the mothers' investment which is most similar to the dependent variable, the prenatal work status of the mother which takes the value of 1 if the mother worked in the year before birth and 0 otherwise.

The descriptive statistics are reported in Table 1. Our sample consists of 59,958 births in 2005-2006. Mothers work an average of 23.77 hours two years after birth. Children weigh

[14]Because for some of the mothers the pregnancy was unexpected, we do not consider the number of cigarettes smoked at the start of the pregnancy as a prenatal investment but rather as characterisitc of the mother.

on average 3599g, which is higher than their mothers (3455g) and similar to their fathers (3594g, shown in the penultimate row of the table). Later born children tend to be slightly heavier at birth than the first (3674g compared to 3492g). Both mothers and fathers have a similar gestation of nearly 40 weeks. Moving onto the covariates, the average age at birth and education of mothers (fathers) is 29 and 13.6 (31.5 and 13.1) and mothers smoke on average 1 cigarette per day at the start of the pregnancy. Fathers in the sample earn on average 433,500 Norwegian Krone in the year after birth and 99% of fathers are recorded as working. In the sample households have an average of 1.82 children and around half of the children are male. Finally the table records statistics for our measures of prenatal investment - prenatal work status (77% of mothers work) and the mean number of cigarettes smoked per day at the end of pregnancy (0.46).

Estimation Results

Table 2 reports the results of our estimation of the mother's behavioural investment response to her first child's birth endowment. The dependent variable is the hours worked 2 years after birth and the variable of interest is child birth weight (in 100g) and its square. All regressions include child month and year of birth dummies and child gender.

Column 1 reports the ordinary least squares (OLS) estimation of the raw regression, which includes no additional controls. Mothers with a first born child with low birth weight work fewer hours and the positive effect of birth weight decreases across the birth weight distribution. This seems to suggest that low health endowments at birth significantly affect mother's labour supply. We interpret this decrease of working hours of mothers with low birth weight children as an increase in the time mothers spend with their child. Of course, this association does not reflect a causal relationship and column 2 controls for demographics, socioeconomic status and proxies for the genetic endowment which are likely to drive the child endowment and post-birth maternal investment. These additional controls include the birth weight and fetal growth of the mother, the mother's age at birth and age squared, the mother's number of cigarettes smoked at the start of the pregnancy, mother and father's education, father's age at birth, earnings and work status in the year after birth. We run a test of joint significance for the coefficients of these added controls and reject that they are jointly equal to zero (the p-value is 0.00). The inclusion of these covariates reduces the magnitude of the coefficients on birth weight and its square.

Even with a large set of controls, the estimates in column 2 are not likely to provide a causal effect as omitted from the model are measures of parental prenatal investments. Column 3 addresses this concern by including in the control variables mother's number of cigarettes smoked at the end of the pregnancy and prenatal work status. Again we test for the joint significance of the coefficients of the new added variables and we find that we can reject strongly the assumption of zero coefficients on the prenatal investments. The inclusion of these prenatal investment controls leads to a further reduction of the effect of birth weight on mother's hours worked; but, By testing the joint significance of the coefficients of birth weight and its square, we find that they are significantly different from zero at 5% level.

The fourth column of Table 2 reports the two-stage least square estimation (2SLS) of the maternal investment response to the child endowment. Despite controlling for observable parental pre-birth investments in column 3, there may be still confounding unobservable investments which cause a bias in our estimates. The two endogenous variables - child birth weight and birth weight squared - are instrumented with the quadratic of the fathers' birth weight. F-statistics from the two first stage regressions are high, confirming that the measure of intergenerational transmission of health at birth from the father to the child is very strong. The F-test for the joint significance of the coefficients of the child birth weight and its square suggests that we can reject the null hypothesis of zero coefficients at 5% level of significance. Furthermore, the endogeneity test reported at the bottom of the table suggests that there are statistically significant differences in the coefficients estimated in column 3 and 4 so that the 2SLS estimation is preferable to the OLS estimation.

A potential concern is that, even after controlling for a wide set of father traits including his age at birth, education, work status and earnings, there remains a direct effect of the fathers' health at birth on the mothers' hours worked after the birth of their child. This would invalidate our instrumental variable strategy through the exclusion restriction. With two endogenous variables and considering two additional instruments given by the father's fetal growth and its square, we can run an overidentification test. The Hansen test p-value is 0.210 which suggests that our instruments are valid.

In an attempt to provide further empirical evidence on the validity of our instrumental variables we also checked the orthogonality between the instruments and the observed prenatal investments conditional on the control variables $\mathbf{X}$. Prenatal investments are usually not observable and their omission can be a major source of endogeneity bias. We find that there is no significant correlation (net of the control variables) between the instruments and the prenatal work status and between the instruments and the smoking behaviour at the end of pregnancy even when considering a 10% level of significance.

Table 3 reports the equivalent estimation results of Table 2 but considering children who are second or later born. We use the same set of explanatory variables used in Table 2 plus the number of children. While the mother's working hours 2 years after the birth of her first child are not affected by the presence of other children because there are very few cases where the birth spacing between first and second born is lower than two years; the mother's working hours after the birth of a second or higher order born child can be affected by the presence of other children. If the presence of more children raises concerns about income more than about time investment, then we expect the marginal effect of child birth weight to be lower for higher order than first born children. To test the validity of our instruments we compute the Hansen overidentification test by considering two additional instruments given by the father's fetal growth and its square. The p-value of Hansen test is far above 0.05 at 0.625 and suggest that our instruments are valid.

The effects of child birth weight in Table 2 and 3 are more easy to compare graphically than by looking at the coefficients of the child birth weight and its square. Figure 1 plots the predicted mother's worked hours against the birth weight separately for first born child and higher order born children using the OLS estimation results in column 3 in Tables 2 and 3. Figure 2 reports the same plot but using the 2SLS estimation results in column 4 in Tables 2 and 3. A comparison of Figures 1 and 2 suggests that the 2SLS estimation seems to better capture an inverted U-shape relationship between mother's labour supply and birth weight, which would be expected if both low birth and extreme large birth weights were related to health issues which lead mothers to reduce their amount of worked hours. We find also that the marginal effect of birth weight, which in Figure 3 is plotted against the child's birth weight, is higher for first born than later born children up to approximately the mean birth weight, suggesting that the presence of other children can attenuate the mothers' investment response to a low birth weight child.

We would like to acknowledge that the estimations In Table 3 ignore the fact that there might be intrahousehold parental responses, which lead mothers to adjust the level of pre-natal investments for second and higher order born children in response to the observed first child birth outcomes (see Del Bono et al. 2012). For example a very low birth weight first born child can lead a mother to adopt a healthier life style during the second pregnancy. If this health style improvement during pregnancy in not observed and leads to a higher birth weight for the second child as well as to a better mother's health after childbirth and a potential increase in her working hours, then we could have a further issue of endogeneity. Notice that while this may affect the estimation results in Table 3, it does not affect results in Table 2 where we focus only on first born children. Furthermore, we believe that our instruments are likely to be uncorrelated with the omitted mother pre-natal investment response to the health endowment of her first born, therefore while the OLS estimations in Table 3 can be biased by the intrahousehold parental response our 2SLS estimation should be consistent.

To make sure that our results are robust to potential misspecification of our model we run some robustness checks whose results are available from the authors upon request. Our dependent variable in all our models is the number of hours worked by mothers, therefore imposing a linear regression could produce a biased estimation because of the mass point at zero. We check this empirically by estimating Tobit models. We find very similar predictions of the effect of birth weight on worked hours and therefore conclude that the assumption of a linear regression model does not invalidate our main conclusions. We also check whether the child's birth weight has an effect on mothers' labour supply at the extensive margin by estimating a probit model. We find an inverted U-shape relationship between the mother's probability to work and her child's birth weight, which suggests that low and extremely high birth weights have a negative effect on the amount of working hours as well as on the labour participation decision. Finally, to check if the assumption of a quadratic polynomial in birth weight is valid we adopt a semiparametric estimation and plot the predicted mother's working hours against the child's birth weight, which still shows inverted U-shape relationship.

In summary our results suggest that mothers adopt a compensating investment strategy, i.e. they tend to decrease their labour supply and invest more time in their newborn child with low or high birth weight, which are likely to lead to serious child health issues.

Comparing our results to other studies which assess the causal effect of child early health on mothers' labour supply, a compensating behaviour for the mother's labour supply is confirmed by the findings in Corman et al. (2005) and Frijters et al. (2009); whereas Zimmer (2007) finds that the effect of the child's health on mother labour supply becomes insignificant when using the instrumental variable estimation, but the instruments are three self-reported measures of difficulty in access to health care and do not seem very powerful.

Many studies have assessed the causal effect of child health at birth on other types of parental investments and results on whether parents compensate or reinforce for low health endowment are mixed. Aizer and Cunha (2012) adopt a siblings difference model and the estimation strategy proposed by Rosenzweig and Wolpin (1988) to correct for any residual endogeneity. They find that children with higher health endowment at birth are more likely to be breastfed than their less healthy siblings, providing evidence of parents' reinforcing investments. On the contrary, Del Bono et al. (2012) find that breastfeeding initiation and duration are negatively related to child-specific endowment, therefore suggesting that mothers compensate for differences between siblings.

Conclusions

This work shows how to estimate the causal effect of the child health endowment at birth on mother's worked hours 2 years after childbirth by using the father's health endowment at birth as an instrument. Our results highlight the importance of controlling for the endogeneity of the child endowment as, even with a large set of controls including close measures for maternal investments during pregnancy, the instrumental variables estimation is preferred to the OLS.

The 2SLS estimation results suggest that mothers adopt a compensating investment behaviour, i.e. they reduce their worked hours when their child's birth weight is low or extremely high. Because these extreme weights are related to health issues, we believe that mothers reduction in worked hours is caused by a concern about their child's health which lead them to invest more time in their child.

A tangible advantage of adopting this instrumental variable estimation is that we were able to allow for a heterogenous response of the mother's investment for first born and later born children. The results suggest a larger reaction to the child health endowment for the first child than the later ones. It is not possible to explore this heterogeneity when using the sibling fixed effect estimation which is usually adopted by existing studies of the parental investment response to child endowments at birth.

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Appendix A: Additional Tables

Table A1: First stage estimation results

	(1) First birth	(2) First birth	(3) 2 or more children	(4) 2 or more children
Endogenous Variable	Child birth weight	Child birth weight squared	Child birth weight	Child birth weight squared
Instrumental Variables				
Father Birth Weight	-0.002***	-0.140***	-0.002***	-0.147***
	(0.000)	(0.034)	(0.000)	(0.028)
Father Birth Weight Squared	0.000***	0.000***	0.000***	0.000***
	(0.000)	(0.000)	(0.000)	(0.000)
Sex male	1.341***	101.573***	1.330***	100.844***
	(0.065)	(4.633)	(0.054)	(3.899)
Mother Birth Weight	0.001***	0.104***	0.001***	0.099***
	(0.000)	(0.014)	(0.000)	(0.012)
Mother Fetal Growth	0.035***	2.653***	0.038***	2.910***
	(0.008)	(0.602)	(0.007)	(0.512)
Mother age at birth	0.254**	17.155**	0.142	8.993
	(0.108)	(7.746)	(0.092)	(6.605)
Mother age at birth squared	-0.005***	-0.318**	-0.003*	-0.177
	(0.002)	(0.130)	(0.002)	(0.109)
Mother education	0.044**	2.365*	0.061***	3.840***
	(0.017)	(1.219)	(0.014)	(1.017)
Father age	0.026**	1.718**	0.023**	1.521**
	(0.011)	(0.813)	(0.010)	(0.688)
Father education	0.003	-0.227	0.004	-0.303
	(0.016)	(1.165)	(0.014)	(0.977)
Father earnings	-0.000	-0.007	-0.000	-0.010*
	(0.000)	(0.009)	(0.000)	(0.005)
Father work status	0.954**	66.567**	0.904***	65.129***
	(0.393)	(28.232)	(0.319)	(22.949)
Number of children			0.256***	19.326***
			(0.043)	(3.122)
Working in year before pregnancy	0.110	5.951	0.274***	17.828***
	(0.079)	(5.670)	(0.065)	(4.669)
Number of cigarettes smoked at start	-0.049***	-3.352***	-0.079***	-5.410***
	(0.015)	(1.062)	(0.012)	(0.851)
Number of cigarettes smoked at end	-0.143***	-10.480***	-0.129***	-9.331***
	(0.022)	(1.583)	(0.017)	(1.200)
Constant	22.433***	412.744***	23.482***	478.244***
	(1.797)	(129.013)	(1.542)	(111.067)
Observations	24,384	24,384	35,574	35,574

Note: Standard errors are in parentheses and are corrected for correlation in the errors within household.

Table A2: Full second stage estimation results for first born children

	(1)	(2)	(3)	(4)
Variable	OLS	OLS	OLS	2SLS
Child birth weight (100g)	0.485***	0.299**	0.217	5.200
	(0.153)	(0.148)	(0.144)	(4.687)
Child birth weight squared	-0.005**	-0.003*	-0.002	-0.076
	(0.002)	(0.002)	(0.002)	(0.063)
Sex male	-0.390*	-0.375*	-0.368*	0.385
	(0.216)	(0.210)	(0.204)	(0.314)
Mother Birth Weight		-0.000	0.000	0.000
		(0.001)	(0.001)	(0.001)
Mother Foetal Growth		-0.004	-0.009	0.010
		(0.027)	(0.026)	(0.028)
Mother age at birth		5.006***	3.475***	3.471***
		(0.345)	(0.338)	(0.367)
Mother age at birth squared		-0.076***	-0.052***	-0.052***
		(0.006)	(0.006)	(0.006)
Mother education		0.827***	0.700***	0.657***
		(0.055)	(0.053)	(0.079)
Father age		0.097***	0.073**	0.067*
		(0.036)	(0.035)	(0.038)
Father education		0.138***	0.169***	0.140**
		(0.052)	(0.051)	(0.059)
Father earnings		-0.001***	-0.002***	-0.002***
		(0.000)	(0.000)	(0.000)
Father work status		6.250***	4.679***	4.802***
		(1.265)	(1.232)	(1.300)
Number of cigarettes smoked at start		-0.196***	-0.026	-0.028
		(0.035)	(0.046)	(0.052)
Working in year before pregnancy			9.074***	8.965***
			(0.247)	(0.289)
Number of cigarettes smoked at end			-0.267***	-0.319***
			(0.069)	(0.075)
Constant	15.132***	-82.780***	-59.759***	-144.687*
	(2.766)	(5.726)	(5.607)	(81.874)
Observations	24,384	24,384	24,384	24,384
R-squared	0.003	0.064	0.115	0.062

Note: Standard errors are in parentheses, *** p<0.01, ** p<0.05, * p<0.1.

OLS and 2SLS are ordinary and two-stage least squares estimations.

Table A3: Full second stage estimation results for later born children

	(1)	(2)	(3)	(5)
Variable	OLS	OLS	OLS	2SLS
Child birth weight (100g)	0.570***	0.386***	0.269**	3.123
	(0.123)	(0.120)	(0.116)	(4.159)
Child birth weight squared	-0.006***	-0.004***	-0.003*	-0.047
	(0.002)	(0.002)	(0.002)	(0.056)
Sex male	-0.427**	-0.439**	-0.401**	0.237
	(0.179)	(0.174)	(0.168)	(0.238)
Mother Birth Weight		0.000	0.000	0.001
		(0.001)	(0.001)	(0.001)
Mother Fetal Growth		-0.009	-0.012	0.009
		(0.023)	(0.022)	(0.023)
Mother age at birth		3.953***	2.632***	2.630***
		(0.290)	(0.282)	(0.301)
Mother age at birth squared		-0.058***	-0.038***	-0.038***
		(0.005)	(0.005)	(0.005)
Mother education		1.009***	0.824***	0.820***
		(0.045)	(0.043)	(0.062)
Father age		0.097***	0.061**	0.058*
		(0.030)	(0.029)	(0.032)
Father education		0.125***	0.139***	0.115**
		(0.043)	(0.042)	(0.054)
Father earnings		-0.001***	-0.001***	-0.001***
		(0.000)	(0.000)	(0.000)
Father work status		7.112***	4.969***	5.278***
		(1.010)	(0.978)	(1.008)
Number of cigarettes smoked at start		-0.163***	-0.025	-0.038
		(0.027)	(0.036)	(0.048)
Number of Children	-3.531***	-3.760***	-2.907***	-2.778***
	(0.134)	(0.136)	(0.133)	(0.139)
Working in year before pregnancy			9.793***	9.794***
			(0.199)	(0.254)
Number of cigarettes smoked at end			-0.165***	-0.206***
			(0.051)	(0.058)
Constant	20.220***	-65.108***	-44.537***	-92.654
	(2.272)	(4.849)	(4.709)	(73.368)
Observations	35,574	35,574	35,574	35,574

Note: Standard errors are in parentheses and are corrected for correlation in the errors within household.

*** p<0.01, ** p<0.05, * p<0.1.

OLS and 2SLS are ordinary and two-stage least squares estimations.

Figure 1: Plot of the OLS predicted mother's hours worked against her child birth weight

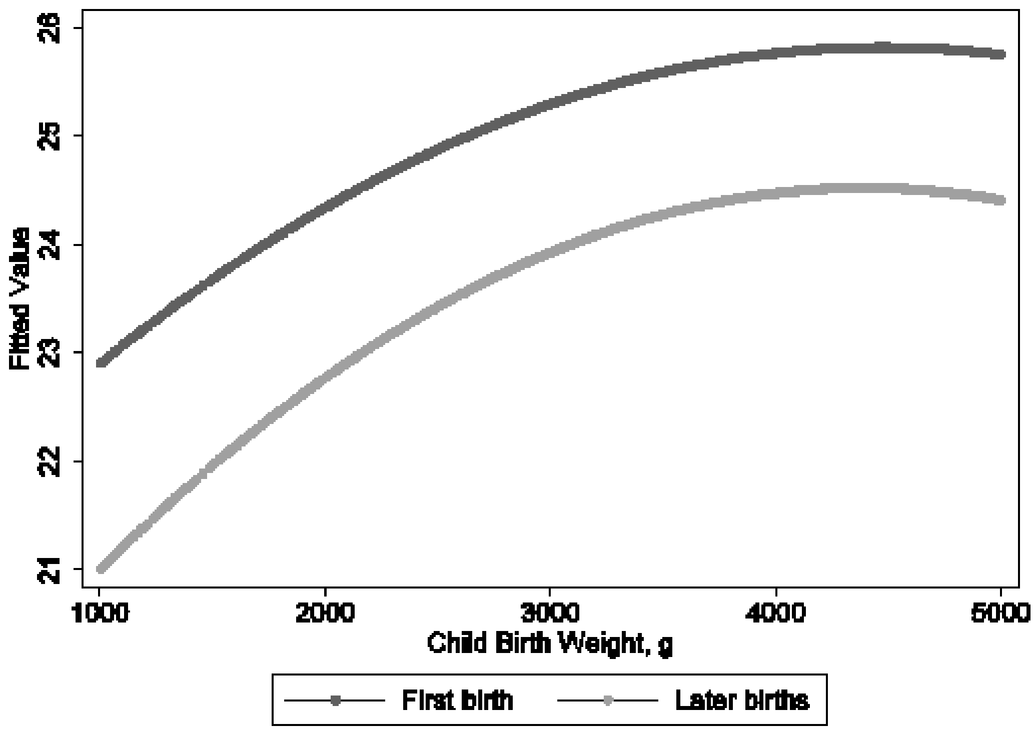

Figure 2: Plot of the 2SLS predicted mother's hours worked against her child birth weight

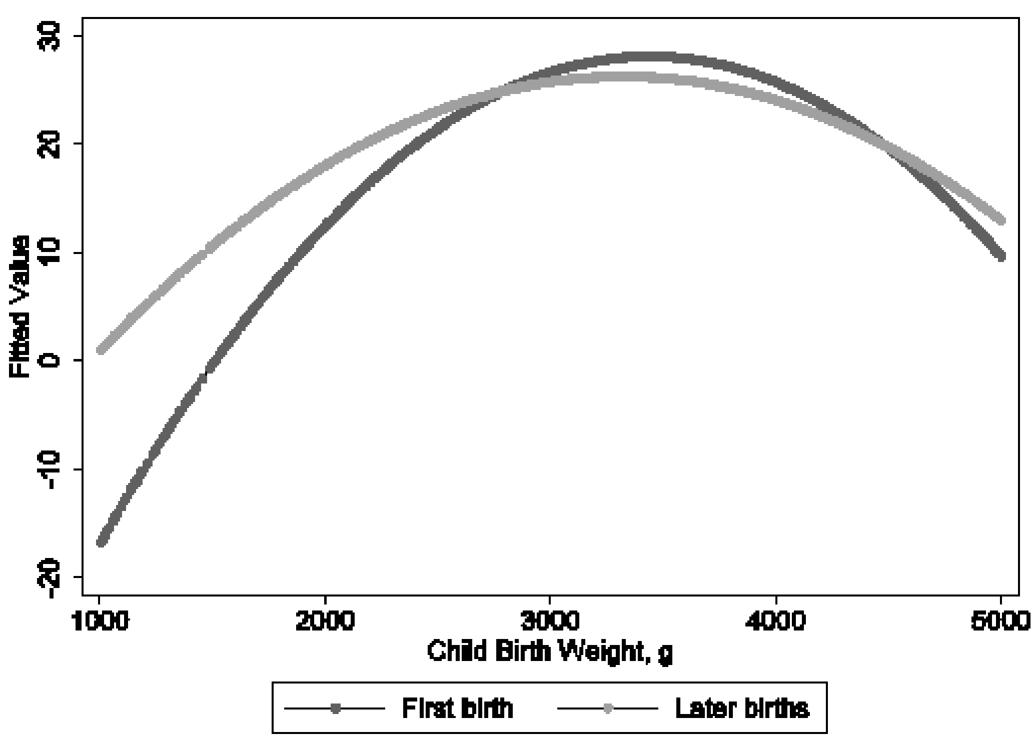

Figure 3: 2SLS predicted marginal effect of child's birth weight on mother's hours worked

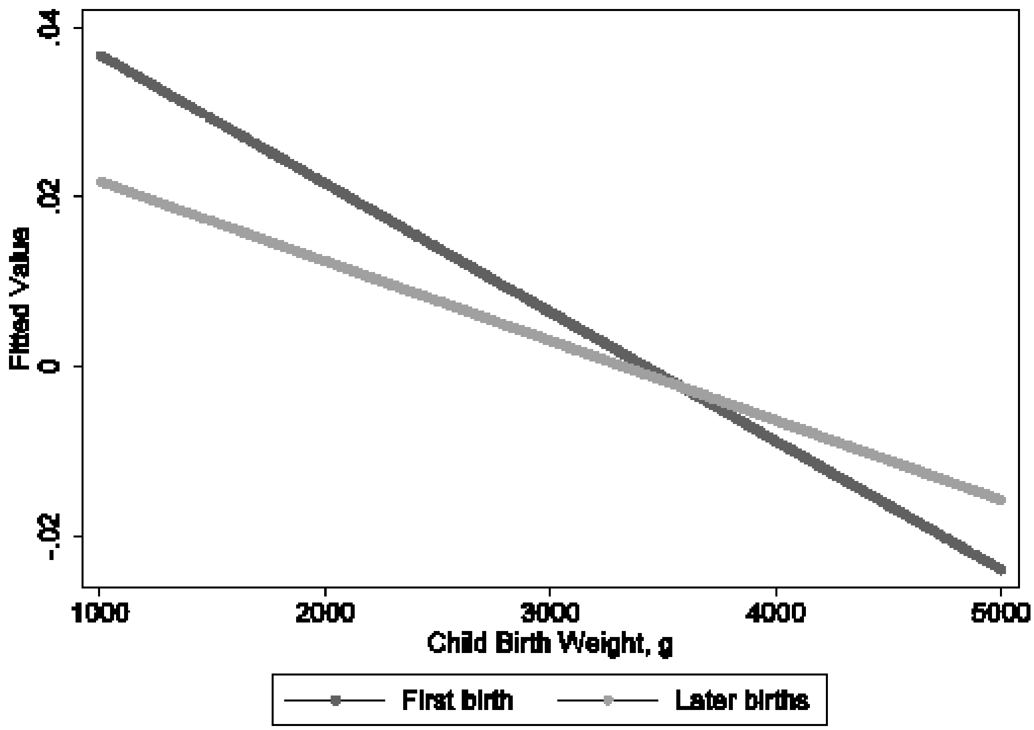

Table 1: Descriptive Statistics

	Mean	Standard Deviation
Mother's postnatal investment		
Mothers hours worked 2 years after birth	23.77	17.37
Endogenous variables		
Child birth weight (g) full sample	3598.83	547.20
First-born child birth weight (g)	3491.61	543.36
Second- and later-born child birth weight (g)	3674.07	537.25
X-Controls: Parental characteristics		
First birth indicator	0.40	0.49
Mother birth weight (g)	3455.12	513.60
Mother gestation (weeks)	39.97	1.90
Mother age at birth	29.05	4.37
Mother years of schooling	13.63	2.35
Number of cigarettes smoked at start of pregnancy	1.00	3.42
Father age at birth	31.54	4.19
Father years of schooling	13.11	2.36
Father annual earnings (K/1000)	433.50	342.43
Father work dummy year after birth	0.99	0.10
X-Controls: Demographic variables		
Number of children	1.82	0.85
Dummy for child male	0.51	0.50
Dummies for year and month of birth (descriptive statistics are omitted for brevity but inclued in all estimated models)		
Controls: Prenatal investments		
Mother prenatal work status	0.77	0.42
Number of cigarettes smoked at end of pregnancy	0.46	2.14
Instrumental variables		
Father birth weight (g)	3594.08	540.73
Father gestation (weeks)	39.84	1.95
No. of observations	59,958	59,958

Table 2: Response of mother's hours worked to birth weight of her first born child

Main Results

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	2SLS
Child birth weight (100g)	0.485***	0.299**	0.217	5.200
	(0.153)	(0.148)	(0.144)	(4.687)
Child birth weight squared	-0.005**	-0.003*	-0.002	-0.076
	(0.002)	(0.002)	(0.002)	(0.063)
F-statistic test of joint significance birth weight and squared	14.87	5.00	3.21	9.41
p-value test of joint significance birth weight and squared	0.000	0.007	0.040	0.000
F-statistic 1st Stage: birth weight				246.12
F-statistic 1st Stage: birth weight squared				263.12
Endogeneity Test p-value				0.00
No. of observations	24,384	24,384	24,384	24,384

Note: Standard errors are in parentheses, *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

OLS and 2SLS are ordinary and two-stage least squares estimations.

Column (1) includes only demographic variables, column (2) controls also for parental characteristics, columns (3) and (4) additionally control for prenatal investments. See Table 1 for a list of the variables.

Table 3: Response of mother's hours worked to birth weight of her later born child

Main Results

	(1)	(2)	(3)	(4)
	OLS	OLS	OLS	2SLS
Child birth weight (100g)	0.570***	0.368***	0.269**	3.123
	(0.123)	(0.120)	(0.116)	(4.159)
Child birth weight squared	-0.006***	-0.004***	-0.003*	-0.047
	(0.002)	(0.002)	(0.002)	(0.056)
F-statistic test of joint significance birth weight and squared	35.64	12.31	6.69	12.64
p-value test of joint significance birth weight and squared	0.000	0.000	0.001	0.000
F-statistic 1st Stage: birth weight				365.06
F-statistic 1st Stage: birth weight^2				394.91
Endogeneity Test p-value				0.010
No. of observations	35,574	35,574	35,574	35,574

Note: Standard errors are in parentheses and are corrected for correlation in the errors within household.

OLS and 2SLS are ordinary and two-stage least squares estimations.

Column (1) includes only demographic variables except no of children, column (2) controls also for parental characteristics, columns (3) and (4) additionally control for prenatal investments.

See Table 1 for a list of the variables.